

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Chung, et al.

Integration of Barrier Layer and Seed Layer

Examiner: Kelly M. Stouffer

Commissioner for Patents
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Alexandria, VA 22313-1450

Dear Sir:

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REPLY BRIEF

Applicants submit this Reply Brief to the Board of Patent Appeals and Interferences on appeal from the decisions of the Examiner of Group Art Unit 1762 dated April 28, 2006, and January 25, 2007, finally rejecting claims 1-7, 9-10, 39, 42, and 44-69. The final rejection of claims 42, 44-52, 60, 62, and 64-66 is appealed. This Reply Brief is believed to be timely as it is filed on or before the due date of March 25, 2007. Please charge any fees that may be required to make this Reply Brief timely and acceptable to Deposit Account No. 20-0782/APPM/006303/KMT.

TABLE OF CONTENTS

1.	Identification Page.....	1
2.	Table of Contents	2
3.	Status of Claims	3
4.	Grounds of Rejection to be Reviewed on Appeal	4
5.	Arguments	5
6.	Conclusion	10

Status of Claims

Claims 1-7, 9-10, 39, 42, and 44-69 are pending in the application. Claims 1-69 were originally presented in the application. Claims 8, 11-38, 40-41, and 43 have been cancelled without prejudice.

Claims 1-7, 9-10, 39, 42, and 44-69 stand finally rejected. The final rejection of claims 42, 44-52, 60, 62, and 64-66 is appealed.

New Grounds of Rejection to be Reviewed on Appeal

1. Claims 42, 44-52, 60-62, and 64-66 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Kobayashi, et al.* (U.S. Patent No. 5,023,698).

2. Claims 42, 44-52, 60-62, and 64-66 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Tsai, et al.* (U.S. Patent No. 6,309,964) and *Kobayashi, et al.* (U.S. Patent No. 5,023,698).

Applicants note that claims 1-7, 9-31, 33-41, 53-59, 63, and 67-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799). However, in view of the new grounds of rejection for claims 42, 44-52, 60-62, and 64-66, Applicants are no longer appealing the rejection of claims 1-7, 9-31, 33-41, 53-59, 63, and 67-69 over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799).

Applicants also note that claims 31, 32, 53-59, 63, and 67-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799), and in further view of *Tsai, et al.* (U.S. Patent No. 6,309,964). However, in view of the new grounds of rejection for claims 42, 44-52, 60-62, and 64-66, Applicants are no longer appealing the rejection of claims 31, 32, 53-59, 63, and 67-69 over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and in further view of *Tsai, et al.* (U.S. Patent No. 6,309,964).

ARGUMENTS IN REPLY TO THE EXAMINER'S ANSWER

1. Argument with respect to the rejection of claims 42, 44-52, 60-62, and 64-66 under 35 U.S.C. § 103(a) over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Kobayashi, et al.* (U.S. Patent No. 5,023,698).

THE EXAMINER ERRED IN REJECTING CLAIMS 42, 44-52, 60-62, AND 64-66 UNDER 35 U.S.C. § 103(A) BECAUSE *LOPATIN, ET AL.* '954 IN VIEW OF *LOPATIN, ET AL.* '799 AND *KOBAYASHI, ET AL.* DOES NOT TEACH OR SUGGEST DEPOSITING A SEED LAYER COMPRISING COPPER AND A METAL OVER A BARRIER LAYER, WHEREIN THE METAL IS ALUMINUM, MAGNESIUM, ZIRCONIUM, OR A COMBINATION THEREOF, AND THE CONCENTRATION OF THE METAL IS BETWEEN ABOUT 0.01 AND ABOUT 5.0 ATOMIC PERCENT OR BETWEEN ABOUT 0.001 ATOMIC PERCENT AND ABOUT 5.0 ATOMIC PERCENT.

Claims 42, 44-52, 60-62, and 64-66 stand rejected under 35 U.S.C. § 103(a) over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Kobayashi, et al.* (U.S. Patent No. 5,023,698) on grounds that it would have been obvious to modify the method of *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 to include the claimed atomic ratios for aluminum in the copper layer as taught by *Kobayashi, et al.* in order to improve electro-migration resistance. Applicants respectfully traverse the rejection.

Lopatin, et al. '954 does not describe a copper seed layer that comprises a metal selected from the group consisting of aluminum, magnesium, zirconium, or a combination thereof. *Lopatin, et al.* '799 describes a seed layer that comprises copper alloyed to a nitrided material such as tin nitride, magnesium nitride, or aluminum nitride in order to provide a nitrided portion 225 of a seed layer 224 that is adjacent to the barrier layer 123 and improves the adhesion of the seed layer to the barrier layer (column 4, lines 6-16, Figure 2, abstract). *Lopatin, et al.* '799 does not disclose the concentration of the tin, magnesium, or aluminum in the seed layer.

Kobayashi, et al. describes adding specific trace amounts of a metal element, such as aluminum, to a copper metallization layer (4 in Figure 3, column 5, lines 9-15) in order to improve the corrosion resistance of the copper metallization layer without lowering the high electro-migration resistance of copper (abstract, column 2, lines 34-41). *Kobayashi, et al.* discloses that the metallization layers comprising the trace amounts of the metal elements provided therein have an electro-migration resistance that is almost equivalent to copper metallization layers (column 5, lines 58-65). Applicants respectfully submit that *Kobayashi, et al.* does not teach that adding the specific trace amounts of the metal element to the copper metallization layer increases the adhesion of the metallization layer to an underlying layer. *Kobayashi, et al.* also does not describe seed layers or suggest adding the specific trace amounts of the metal elements described therein to a copper seed layer to improve adhesion of the copper layer to an underlying barrier layer. Applicants respectfully submit that the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, and *Kobayashi, et al.* does not teach or suggest that the amounts of aluminum that *Kobayashi, et al.* includes in copper metallization layers to prevent corrosion of the copper layers may be added to the nitrogen and aluminum-containing copper seed layer that *Lopatin, et al.* '799 provides to enhance adhesion to a barrier layer. Therefore, the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, and *Kobayashi, et al.* does not teach or suggest depositing a copper alloy seed layer over a barrier layer, with the seed layer comprising a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof and in a concentration between about 0.01 atomic percent and 5.0 atomic percent.

Thus, *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and further in view of *Kobayashi, et al.* does not teach, show, or suggest a method of filling a feature, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, and then depositing a copper conductive material layer over the

copper alloy seed layer, as recited in claim 42. Applicants respectfully request withdrawal of the rejection of claim 42 and of claims 44-46, which depend thereon.

Similarly, *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and further in view of *Kobayashi, et al.* does not teach, show, or suggest a method of filling a feature, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, depositing a second seed layer over the copper alloy seed layer, and then depositing a copper conductive material layer over the second seed layer, as recited in claim 47. Applicants respectfully request withdrawal of the rejection of claim 47 and of claims 48-52, which depend thereon.

Claims 60-62 and 64-66 include the element of depositing a seed layer on a barrier layer, wherein the seed layer comprises copper and aluminum in a concentration between about 0.001 atomic percent and about 5.0 atomic percent. Applicants respectfully submit that the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, and *Kobayashi, et al.* does not teach or suggest that the amounts of aluminum that *Kobayashi, et al.* includes in copper metallization layers to prevent corrosion may be added to the nitrogen and aluminum-containing copper seed layer that *Lopatin, et al.* '799 provides to enhance adhesion to a barrier layer. Therefore, the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, and *Kobayashi, et al.* does not teach or suggest depositing a seed layer over a barrier layer, with the seed layer comprising copper and aluminum in a concentration between about 0.001 atomic percent and 5.0 atomic percent. Thus, *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and *Kobayashi, et al.* does not teach or suggest all of the elements of claims 60-62 and 64-66. Applicants respectfully request withdrawal of the rejection of claims 60-62 and 64-66.

2. **Argument with respect to the rejection of claims 42, 44-52, 60-62, and 64-66 under 35 U.S.C. § 103(a) over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Tsai, et al.* (U.S. Patent No. 6,309,964) and *Kobayashi, et al.* (U.S. Patent No. 5,023,698).**

THE EXAMINER ERRED IN REJECTING CLAIMS 42, 44-52, 60-62, AND 64-66 UNDER 35 U.S.C. § 103(A) BECAUSE *LOPATIN, ET AL.* '954 IN VIEW OF *LOPATIN, ET AL.* '799, *TSAI, ET AL.* AND *KOBAYASHI, ET AL.* DOES NOT TEACH OR SUGGEST DEPOSITING A SEED LAYER COMPRISING COPPER AND A METAL OVER A BARRIER LAYER, WHEREIN THE METAL IS ALUMINUM, MAGNESIUM, ZIRCONIUM, OR A COMBINATION THEREOF, AND THE CONCENTRATION OF THE METAL IS BETWEEN ABOUT 0.01 AND ABOUT 5.0 ATOMIC PERCENT OR BETWEEN ABOUT 0.001 ATOMIC PERCENT AND ABOUT 5.0 ATOMIC PERCENT.

Claims 42, 44-52, 60-62, and 64-66 stand rejected under 35 U.S.C. § 103(a) over *Lopatin, et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin, et al.* (U.S. Patent No. 6,174,799) and further in view of *Tsai, et al.* (U.S. Patent No. 6,309,964) and *Kobayashi, et al.* (U.S. Patent No. 5,023,698) on grounds that it would have been obvious to modify the method of *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 to use a barrier layer having a thickness of 10 angstroms as described by *Tsai, et al.* The Examiner also states that it would have been obvious to modify the method of *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and *Tsai, et al.* to include the claimed atomic ratios for aluminum in the copper layer as taught by *Kobayashi, et al.* in order to improve electro-migration resistance. Applicants respectfully traverse the rejection.

As discussed above in the first argument, the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, and *Kobayashi, et al.* does not teach or suggest using the amounts of aluminum that *Kobayashi, et al.* includes in copper metallization layers to prevent corrosion in the nitrogen and aluminum-containing seed layer that *Lopatin, et al.* '799 provides to enhance adhesion to a barrier layer. Applicants further submit that the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, *Kobayashi, et al.*, and *Tsai, et al.* does not teach or suggest using the amounts of aluminum that *Kobayashi, et al.*

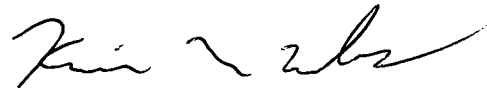
includes in copper metallization layers to prevent corrosion in the nitrogen and aluminum-containing seed layer that *Lopatin, et al.* '799 provides to enhance adhesion to a barrier layer. As the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, *Kobayashi, et al.*, and *Tsai, et al.* does not teach or suggest depositing a copper alloy seed layer over a barrier layer, with the seed layer comprising a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof and in a concentration between about 0.01 atomic percent and 5.0 atomic percent, *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and further in view of *Tsai, et al.* and *Kobayashi, et al.* does not teach or suggest all of the elements of claims 42 and 44-52. Applicants respectfully request withdrawal of the rejection of claims 42 and 44-52.

Similarly, the combination of *Lopatin, et al.* '954, *Lopatin, et al.* '799, *Kobayashi, et al.*, and *Tsai, et al.* does not teach or suggest depositing a copper alloy seed layer over a barrier layer, with the seed layer comprising aluminum in a concentration between about 0.001 atomic percent and 5.0 atomic percent. Thus, *Lopatin, et al.* '954 in view of *Lopatin, et al.* '799 and further in view of *Tsai, et al.* and *Kobayashi, et al.* does not teach or suggest all of the elements of claims 60-62 and 64-66. Applicants respectfully request withdrawal of the rejection of claims 60-62 and 64-66.

CONCLUSION

For the reasons presented above, Applicants respectfully submit that the rejections of claims 42, 44-52, 60-62, and 64-66 are improper. Thus, Applicants respectfully request reversal of the rejections and allowance of claims 42, 44-52, 60-62, and 64-66.

Respectfully submitted,



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